UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/050,570	01/18/2002	Kuniaki Yagi	Q68148	7078

23373 7590 03/10/2004

SUGHRUE MION, PLLC
2100 PENNSYLVANIA AVENUE, N.W.
SUITE 800
WASHINGTON, DC 20037

EXAMINER	
SONG, MATTHEW J	
ART UNIT	**PAPER NUMBER**
1765	

DATE MAILED: 03/10/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/050,570	YAGI ET AL.	
	Examiner	Art Unit	
	Matthew J Song	1765	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *22 December 2003*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1 and 3-11* is/are pending in the application.

4a) Of the above claim(s) *6-10* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,3-5 and 11* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *9/25/2003*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 12/22/2003 has been entered.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claims 1, 3-5 and 11 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter, which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 1 recites, "heating the substrate under existence of a raw material containing C or **Si, or C and Si** to induce surface chemical reaction between said raw material and Si or C contained in the substrate, thereby forming the thin single crystal film" in lines 5-7. The instant specification merely teaches using C_2H_2 as a material gas to form a SiC layer on a Si substrate, note pages 11 and 15 of the instant specification. The instant specification does not provide

support for Si or C and Si to induce surface chemical reactions. Furthermore, claim 4 requires the addition of material containing Si in addition to material containing C, which is well known in the art to be a chemical vapor deposition process and does not induce surface chemical reaction because the reaction occurs in the vapor phase. In other words, the addition of a silicon containing gas would induce a vapor phase chemical reaction with the carbon containing gas and not a surface reaction claimed by applicants.

4. Claims 1, 3-5 and 11 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject matter, which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Claim 1 recites, "heating the substrate under existence of a raw material containing C or Si, or C and Si to induce surface chemical reaction between said raw material and Si or C contained in the substrate, thereby forming the thin single crystal film" in lines 5-7. The specification does not teach how to induce surface chemical reactions because Funato et al (US 5,882,807) and Suzuki et al (US 5,985,091) teaches using similar reactive gases, as applicants have claimed in instant claim 5, and similar temperatures and substrates, as applicant, which result in chemical vapor deposition and not surface reactions. Therefore, one skilled in the art would not be able to induce surface reactions because similar methods result in chemical vapor deposition.

5. Claims 1, 3-5 and 11 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject matter, which was not described

in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Claim 4 recites, "at least one material selected from the group consisting of .....is used as the material containing Si and used in the first step of forming the single crystal SiC layer in addition to the material containing C" in lines 2-4. Claim 1 recites, "heating the substrate under existence of a raw material containing C or Si, or C and Si to induce surface chemical reaction between said raw material and Si or C contained in the substrate, thereby forming the thin single crystal film" in lines 5-7. Claim 4 is assumed to be properly dependent, which claims the addition of silicon containing gas and carbon containing gas to form a SiC layer by inducing surface chemical reactions. The specification does not enable one of ordinary skill in the art to prevent vapor phase reactions and induce surface chemical reaction because using silicon and carbon containing gases would form the SiC layer by chemical vapor deposition because the use of the carbon and silicon containing gases are well known in the art to be use in chemical vapor deposition.

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various

claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

2. Claims 1, 3 and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kito et al (US 6,110,279) in view of Cook et al (US 6,352,594) and Mogab et al ("Conversion of Si to epitaxial SiC by reaction with C_2H_2").

Kito et al discloses a silicon carbide single crystal layer **15**, this reads on applicant's substrate, and forming a silicon carbide single crystal layer **19a** by a CVD method where, the temperature of silicon carbide layer **15** is increased to be 1500°C and source gases of SiH_4 and C_3H_8 are introduced (col 12, ln 1 to col 13, ln 15). Kito et al also discloses a silicon carbide single crystal ingot **19** is formed on the single crystal layer **19a** by the sublimation-recrystallization method (col 13, ln 15-67), this reads on applicant's depositing SiC by the vapor phase growth method.

Kito et al does not disclose the raw material is supplied in the vicinity of the surface of the substrate and the raw material in the vicinity of the surface of the substrate is given a partial pressure higher at least by a predetermined rate than that of an impurity, thereby suppressing the impurity from reaching the surface of the substrate and preventing the surface of the substrate from being etched by the impurity.

In an improved method of CVD, note entire reference, Cook et al teaches the amount of incorporation of unwanted impurities in CVD films is proportional to the partial pressure of such impurity molecules, this is a teaching that the partial pressure is a result effective variable, and the reduction of impurities in the film produced is due to the reduced partial pressure of impurities in the gas stream above the wafers surface resulting from the increased concentration, this reads on applicant's partial pressure, of the desired reactant species in the gas stream (col 7, ln 65 to col 8, ln 67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Kito et al with Cook et al's CVD method of reducing the partial pressure of impurities by increasing the concentration of reactants to reduce the amount of impurities in a film.

The combination of Kito et al and Cook et al teach CVD, as a method of depositing a SiC layer. The combination of Kito et al and Cook et al does not teach a surface chemical reaction between said raw material and Si or C contained in the substrate, thereby forming the thin single crystal film.

In a method of forming SiC, note entire reference, Mogab et al teaches the formation of epitaxial SiC on Si single crystal by reaction with C_2H_2 in HV and UHV systems (pg 1075), this reads on applicant's coating a substrate with a thin single crystal SiC layer by heating under the existence of a raw material containing C to induce surface chemical reaction. Mogab et al also teaches Si wafers were heated by radiation from a tungsten-halogen lamp and initiation of the reaction occurred by introduction of acetylene followed by rapid heating of the wafer (< 1 min) to the reaction temperature (pg 1076). Mogab et al also teaches a reaction temperature of 950-1100°C (pg 1077 and Fig 1). It would have been obvious to a person of ordinary skill in the art at

the time of the invention to modify the combination of Kito et al and Cook et al by using the method of forming SiC taught by Mogab et al because in a smooth and defect free films (pg 1078), which are desirable.

The combination of Kito et al, Cook et al and Mogab et al is silent to the first step comprising a temperature elevating step of elevating the temperature of the substrate from a first temperature at which etching of the surface of the substrate by the impurity is started to a second temperature at which the thin single crystal layer is formed and the temperature elevating step being carried out at a temperature elevating rate equal to or higher than 150°C/minute.

The combination of Kito et al, Cook et al and Mogab et al teach using a tungsten-halogen lamp for heating a substrate to a reaction temperature of 950-1100°C at a rapid rate (<1 min), note pages 1076-1077 of Mogab et al. The combination of Kito et al, Cook et al and Mogab et al teach the wafer is heated to a growth temperature of 950-1100°C and applicants teach the first temperature is 800°C on page 15 of the instant specification; therefore a first temperature is inherent to the combination of Kito et al, Cook et al and Mogab et al because wafer is heated to the reaction temperature, which is higher than 800°C. The heating rate is also inherent to the combination of Kito et al, Cook et al and Mogab et al because the combination of Kito et al, Cook et al and Mogab et al teach heating to a reaction temperature of 950-1100°C at a rapid rate of less than 1 min, which is equivalent to approximately 900°C/min, which is with the claimed range of 150°C/minute. Furthermore, tungsten-halogen lamps are well known in the art to be used for heating rate exceeding 100°C/sec (6000°C/min), note Kohav et al (US 6,084,213) below.

Referring to claim 1, the combination of Kito et al, Cook et al and Mogab et al is silent to the raw material in the vicinity of the surface of the substrate is given a partial pressure higher than 100 times that of the impurity. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Kito et al, Cook et al and Mogab et al by optimizing the partial pressure of the raw material to be 100 times that of the impurity by conducting routine experimentation of a result effective variable (MPEP 2144.05) because a larger amount of raw material will reduce the partial pressure of the impurities, which reduces the amount of impurities in the films produced ('594 col 8, ln 15-30).

Referring to claim 3, the combination of Kito et al, Cook et al and Mogab et al teaches C_2H_2, which reads on applicant's C_nH_{2n-2} ($1 \leq n \leq 3$) when n=2.

Referring to claim 11, the combination of Kito et al, Cook et al and Mogab et al teaches a silicon wafer **14** (col 6, ln 35-50), this reads on applicant's Si substrate.

3. Claim 4 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kito et al (US 6,110,279) in view of Cook et al (US 6,352,594) and Mogab et al ("Conversion of Si to epitaxial SiC by reaction with C_2H_2") as applied to claims 1, 3 and 11 above, and further in view of Eshita et al (US 4,855,254).

The combination of Kito et al, Cook et al and Mogab et al teach all of the limitations of claim 4, as discussed previously, except a material containing Si is used in the first step of forming the single crystal SiC layer in addition to the material containing C.

In a method of making SiC, note entire reference, Eshita teaches a silicon substrate is heated while feeding acetylene to carbonize the surface layer of the silicon layer (col 4, ln 4, ln

10-65). Eshita et al also teaches a silicon carbide layer is formed by supplying dichlorosilane or trichlorosilane in addition to acetylene or propane to from a SiC layer (col 4, ln 65 to col 5, ln 35). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Kito et al, Cook et al and Mogab et al with the silane gas taught by Eshita et al to form a desirable single crystalline SiC.

4. Claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kito et al (US 6,110,279) in view of Cook et al (US 6,352,594) and Mogab et al ("Conversion of Si to epitaxial SiC by reaction with C_2H_2") as applied to claims 1, 3 and 11 above, and further in view of Eshita et al (US 4,855,254), as applied to claim 4 above, and further in view of Suzuki (US 5,985,091).

The combination of Kito et al, Cook et al, Mogab et al and Eshita et al teach all of the limitations of claim 5 including a silane precursor, as discussed previously, except at least one material is selected from the claimed group of materials.

In a method of chemical vapor deposition, note entire reference, Suzuki teaches a material containing Si atoms when a semiconductor thin film of SiC is formed, where silanes such as SiH_4 or organic silanes such as tetramethylsilane ($Si(CH_3)_4$), dimethylsilane, $SiHCl_3$, SiH_2Cl_2 or tetraethylsilane can be used (col 6, ln 15-30). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Kito et al, Cook et al, Mogab et al and Eshita et al with Suzuki's Si containing material as a source because substitution of known equivalents for the same purpose is held to be obvious. (MPEP 2144.06).

Response to Arguments

5. Applicant's arguments with respect to claims 1, 3-5 and 11 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Larkin et al (US 5,709,745) teaches controlling the concentration of the crystal growing components in a growth chamber, thereby controlling impurity incorporation into the growth sites (Abstract).

Shoimi et al (US 2001/0000864) teaches a SiC deposition using a solid source Si resulting in the partial pressure of hydrogen in the atmosphere to decrease, thereby eliminating the problem of etching [0018].

Shoimi et al (EP 0933450) is equivalent to US 2001/0000864.

Hamakawa et al (US 5,021,103) teaches a hydrogen dilution rate in a mixture gas for forming Silicon carbide is equal to the partial pressure of hydrogen divided by the sum of the partial pressures of carbon containing species and silicon containing species (col 3-4).

Hamza et al (US 5,861,346) teaches a surface reaction with a Silicon substrate and a carbon source to form crystalline SiC (col 3, ln 1-20).

Kohav et al (US 6,084,213) teaches a rapid thermal process, where wafer heated by tungsten-halogen lamps at a high heating rate approaching or exceeding 100°C/sec (col 1, ln 20-30).

Steckel et al (US 5,759,908) teaches a silicon layer is converted to a SiC layer by exposing the substrate to a hydrocarbon gas at an elevated temperature (col 3, ln 1-50).

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 571-272-1468. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on 571-272-1465. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Matthew J Song
Examiner
Art Unit 1765

MJS

NADINE G. NORTON
PRIMARY EXAMINER